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THE COLORIMETRIC DESIGN OF RED SIGNAL GLASSES

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A RED signal glass has two desirable properties from a utilitarian viewpoint—intense redness for distinctiveness and a high light transmission for brilliance and efficiency. These characteristics are mutually antagonistic in the sense that high values of one correspond to low values of the other. This paper will describe the color and light transmission of red glasses in colorimetric terms and interpret these in terms of spectrophotometric curves in order that the best compromise of these desirable properties can be obtained. The range of possibilities is of interest to those considering specifications for red signals. The chromaticity of various reds is most clearly shown on the color diagram, Fig. 1. An enlarged portion of the diagram is shown in Fig. 2. Although for computational convenience the diagram is plotted in terms of two of the three trilinear coordinates x, y and z, it is more readily understood as a polar diagram in which the white point is the pole, angular position corresponds to hue and radial distance corresponds to saturation. Although any color can be exactly described by its values of x and y,[1] yet a description in terms of dominant wave length and colorimetric purity is more immediately comprehensible.

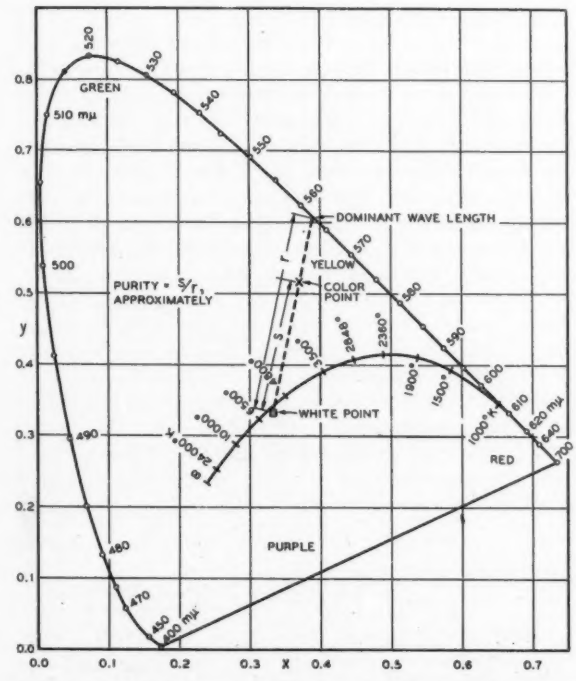


Fig. 1. Color Diagram According to the 1931 I. C. I. System.

Dominant wave length is a measure of hue and is that wave length at which a line drawn through the white point and the color point intersects the spectrum locus. Purity is a measure of color saturation and is the ratio[2] of the distances of the color point and spectrum locus from the white point. The spectrum colors are saturated (purity=1.00) and appear in order around the edge of the diagram. Since mixture colors lie on the straight

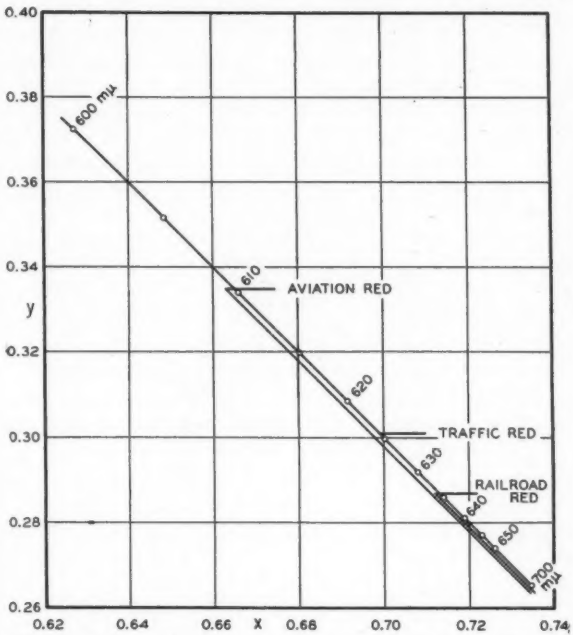


Fig. 2. Red Portion of Color Diagram Showing Specification Limits.

line joining their components all saturated purples lie on the line connecting the deepest violet and red. White corresponds to an equal distribution of spectral energy and this color is located at $x=0.333$, $y=0.333$. All possible colors lie within the boundaries of this diagram, saturated colors near the spectrum locus and unsaturated tints near the white point. For example the locus of all color temperature colors is seen to be identical with the spectrum colors in the deep red, branching away and sweeping close to the white point and vanishing in a region bluish white in color.

This system for describing colors is independent of the characteristics of individual observers, has been inter-

[1] The trilinear coordinates x, y and z are adjusted to make their sum equal to unity. Hence the value of any one can be found from the others.
[2] This ratio is approximate. More exact methods are discussed in reference 3.

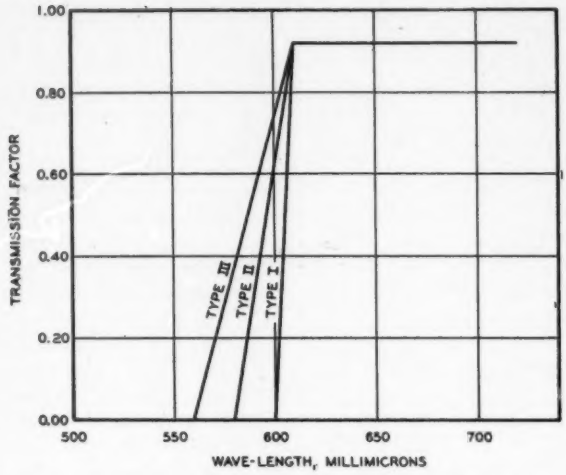


Fig. 3. Three Typical Simplified Spectrophotometric Curves.

nationally standardized by the I. C. I.[3] and serves as a ready means of interpreting spectrophotometric data in colorimetric terms.

It should be made clear that the chromaticity diagram describes the color of *colored light* and not (directly at least) the properties of *colored objects*. In order to describe a colored object in terms of the colored light which it transmits or reflects the color of the illuminant must be considered. Since the present discussion has particular application to red signal colors produced by the light from automobile headlamps (reflex devices, tail lamp glasses) or produced by the light from traffic signals, the computations to follow will use I. C. I. Illuminant A, tungsten light at 2848 K, color temperature.

There is no one answer to the question "How red should a red signal be?" but such specifications as are available are written in terms readily shown on the chromaticity diagram. For example the Bureau of Air Commerce defines Aviation Red as a color for which the trilinear coordinates y and z are not greater than 0.335 and 0.002 respectively.[4, 5] A red for automotive use has been proposed[6] in terms of dominant wave length and colorimetric purity. These specifications are readily plotted on the chromaticity diagram and represent colors for which the trilinear coordinates y and z are not greater than 0.301 and 0.000 respectively. Railroad red has been defined by the American Association of Railroads[7] as a color for which the trilinear coordinates y and z shall be not greater than 0.287 and 0.001 respectively. The areas of permissible colors under these specifications are shown in Fig. 2, which is an enlarged portion of the lower right hand corner of Fig. 1. The traffic red, having

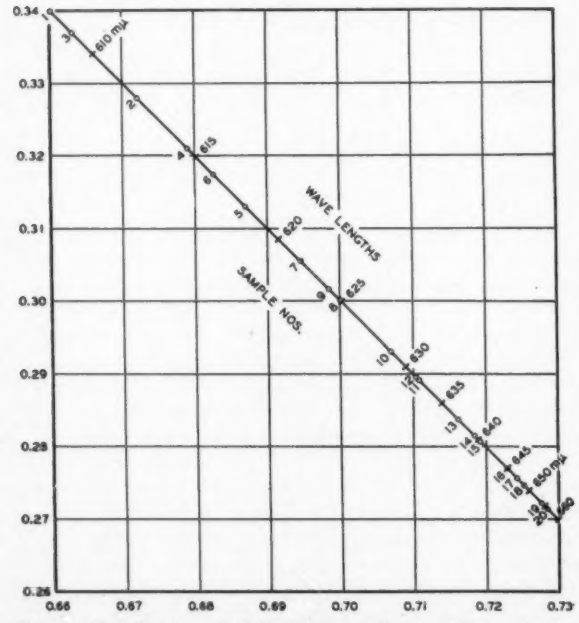


Fig. 4. Red Portion of Color Diagram Showing Chromaticities of Selected Spectrophotometric Curves.

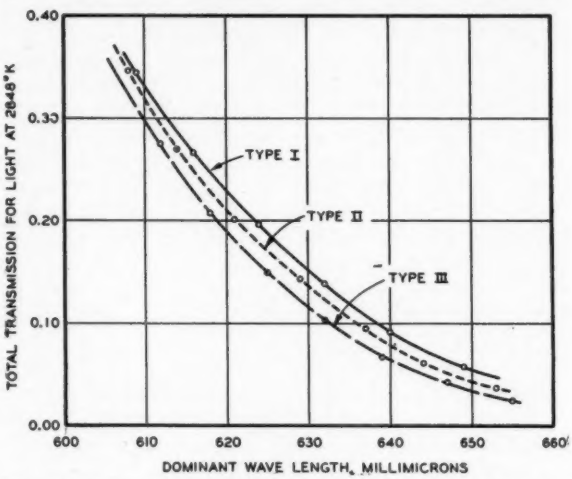


Fig. 5. Chromaticity and Light Transmission of Selected Spectrophotometric Curves.

no allowable values of z can not be shown as an area but in practice it is found that z is practically zero for sharp cut-off red glasses.

Actual red glasses are fundamentally described by their spectrophotometric curves and the following will correlate idealized or approximately attainable spectrophotometric curves of red glasses with their corresponding colors. It has been shown by MacAdam[8] that the maximum light transmission for a given chromaticity is obtained when the spectrophotometric curve for the material has at all wave lengths the value zero or 100 per cent with not more than two discontinuous transitions of the curve between these values. When this principle is applied to red glasses we find that for maximum light transmission for a given color the spectrophotometric curve should rise as abruptly as possible from zero to 92 per cent transmission[9] by a transition having the steepest possible slope and that the 92 per cent transmission should continue to the red limit of the visible spectrum. Catalog curves of red filter glasses indicate that slopes corresponding to a wave length difference of 30 millimicrons are common. The toe and shoulder por-

[3] D. B. Judd: The 1931 I. C. I. Standard Observer and Coordinate System for Colorimetry, J. O. S. A. 23, 359 (1933).
[4] Performance Specifications for Airport Lighting Equipment and Materials. Bureau of Air Commerce, Airport Section, Washington, D. C.
[5] F. C. Breckenridge: The Airport Lighting Specifications of The Department of Commerce, I. E. S. Trans. (In press).
[6] American Standard Colors for Traffic Signals. ASA D3-1927.
[7] A. A. R. Signal Section Specification 69-35 (March 1935).
[8] D. L. MacAdam: The Theory of the Maximum Visual Efficiency of Colored Materials, J. O. S. A. *25*, 249 (1935).
[9] This transmission value represents no absorption but only unavoicable losses due to surface reflections.

tions at the lower and upper ends of the curves cover a wider wave length range.

In an effort to map out the red portion of the diagram in terms of practical spectrophotometric curves, the colors of the three simplified types of curves shown in Fig. 3 have been computed. Type I rises from zero to 92 per cent in 10 millimicrons, type II and type III rise in 30 and 50 millimicrons respectively. The color position of a group of curves of the three types is shown on the chromaticity diagram, Fig. 4. The data on these colors are shown in the table below. Note that the dominant wave length is much more red than the cut-off wave length.

COLORIMETRIC DATA ON ALL SAMPLES

Sample No.	λ_c	Type	λ_d	x	y	z	T_w
1	570	II	608	0.6599	0.3398	0.0003	0.347
2	570	III	612	0.6717	0.3281	0.0002	0.276
3	580	I	609	0.6632	0.3366	0.0002	0.345
4	580	II	614	0.6788	0.3210	0.0002	0.270
5	580	III	618	0.6873	0.3125	0.0002	0.208
6	590	I	616	0.6826	0.3172	0.0002	0.267
7	590	II	621	0.6946	0.3053	0.0001	0.201
8	590	III	625	0.7003	0.2996	0.0001	0.150
9	600	I	624	0.6984	0.3015	0.0001	0.197
10	600	II	629	0.7070	0.2930	0.0000	0.143
11	600	III	632	0.7107	0.2893		0.104
12	610	I	632	0.7104	0.2896		0.139
13	610	II	637	0.7163	0.2837		0.096
14	610	III	639	0.7185	0.2815		0.068
15	620	I	640	0.7191	0.2809		0.092
16	620	II	644	0.7229	0.2771		0.061
17	620	III	647	0.7243	0.2757		0.043
18	630	I	649	0.7252	0.2748		0.058
19	630	II	653	0.7276	0.2724		0.037
20	630	III	655	0.7284	0.2716		0.025

In the above table λ_c and λ_d denote the cut-off and dominant wave lengths respectively and T_w denotes the white light transmission.

Note that the position points of even the type III curves lie practically on the spectrum locus in Fig. 4, showing that practically 100 per cent purity is easily achieved in colors of this sort. The total light transmission (computed for light at 2848 K) decreases with increasing dominant wave length and decreases as the sharpness of cut-off is reduced. These results are in full accord with MacAdams' theory discussed above. The light transmission plotted against dominant wave length is shown in Fig. 5. In this figure the three types of spectrophotometric curves are shown separately.

Once a light chromaticity limit or minimum dominant wave length has been chosen as a manufacturing standard the aim of production should be to supply glasses which:—

(a) are close to the light chromaticity limit

(b) have the steepest possible cut-off

(c) have the maximum possible transmission in the flat part of the curve and

(d) have highest possible total light transmission.

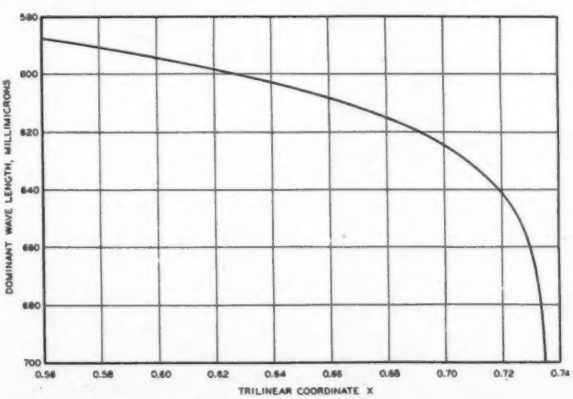


Fig. 6. Dominant Wave Length as a Function of the x Coordinate of the Spectrum Locus.

A complete study of actual glasses involves first making a spectrophotometric curve. From this are computed the colorimetric quantities x, y, z and T_w for an illuminant at 2848 K. The dominant wave length can be determined by estimation between marked wave lengths in Fig. 4 or by the use of Fig. 6 in which a curve is drawn between dominant wave length and the trilinear coordinate x for the spectrum locus. If the dominant wave length of the sample is greater than the standard value selected, then the sample is acceptable for color and its excellence is proportional to its light transmission.

In routine checking of production a photometer can be used in connection with a standard glass which represents the light chromaticity limit. The operator compares sample and standard, rejecting samples which appear less red than the standard. The light transmission of the acceptable pieces are measured at the same time.

No paper on red signal glass design would be complete without acknowledging the work of K. S. Gibson and of H. P. Gage who have been instrumental in developing specifications, a photometric scale and inspection methods for railroad colored signal glasses.

COLOR TEMPERATURE OF TUNGSTEN-FILAMENT LAMPS

When a seasoned incandescent lamp is burned at constant voltage, its chromaticity is not quite constant but changes slowly toward yellow. This chromaticity is conveniently and customarily specified by color temperature, defined as the temperature which a completely enclosed space, such as in a furnace, would need to have in order to yield the same chromaticity by thermal radiation. The light output of the lamp also decreases.

An investigation was begun in 1930 by Deane B. Judd of the colorimetry section, with the primary purpose of discovering which of a number of types of tungsten-filament incandescent lamps was best suited for standards of color temperature. It was also expected that the study would show how much a working standard could be used before a check against a primary standard was advisable.

As a result of this investigation, which is described in RP937 of the *Journal of Research* for November, 400-watt projection lamps have been chosen as lamp standards of color temperature; this type of lamp was found to be as permanent as specially built photometric-standard lamps, and it is also a less expensive and more convenient type. The color temperature decreases when seasoned lamps of this type are burned at about 2,850° K by an average of less than one-tenth of a degree per hour. The rate of decrease is nearly proportional to the twenty-third power of the filament temperature, and is ascribed largely to the accumulation of the familiar brown deposit on the inside of the bulb. The effect of operating unseasoned lamps at constant voltage was found to be a rapid rise in color temperature extending over about half an hour, and amounting to nearly 100° K at 3,100° K.—*Technical News Bulletin of the National Bureau of Standards, November, 1936.*

A. S. M. E. HONORS DR. BAUSCH

Dr. Edward Bausch and Henry Ford shared honors on the evening of Dec. 1 when the American Society of Mechanical Engineers made its annual awards for distinguished service in engineering and science, and "for great and unique acts of an engineering nature that have accomplished a great and timely benefit to the public." Dr. Bausch will receive the A. S. M. E. medal and Mr. Ford will receive the Holley medal. The A. S. M. E. medal, according to a bulletin of the Society, is awarded once a year, "and that only for inventions and improvements of great merit in the technical and public sense." Among the previous recipients have been Hjalmar Gotfried Carlson, Dr. Robert A. Millikan, Dr. Ambrose Swasey and other distinguished contributors to the progress of engineering.

In his long and notable career, which began with the construction of his first microscope in 1872, Dr. Bausch has been a constant contributor to engineering progress, as partially indicated by some 40 patents. His latest work, which he shares with other members of the Scientific Bureau, is the design of a Contour Measuring Projector.

This instrument is both a microscope and a projection apparatus with which a highly magnified image of such parts as screw threads, gears, dies, hobs, gages and shapers may be profiled upon a screen or chart. The value of such an instrument in quickly solving many of the irritating problems of mass production is due to its ability to show quickly the magnitude of error in machine tools and parts.

NEW RESEARCH ON OPTICAL GLASS

A broad program of fundamental investigations on the chemistry and physics of glass surfaces to aid in the development of scientific apparatus and ophthalmic instruments has been started at Mellon Institute of Industrial Research by the Bausch & Lomb Optical Co. The first studies will be concerned with the effects of environmental factors on the durability of the various types of glass used in optical instruments. Bausch & Lomb, whose research in optical glass dates from the initial work of William Bausch in 1912, has maintained a fellowship at Mellon Institute since 1931 for research on various plant and production problems in optical technology. New developments in the past have included improved greases for optical instruments, cements for ultraviolet transmitting optics, improved methods for making and testing mirrors and reflectors, and standardization of the sizes of fine abrasives used in grinding lenses. Dr. Frank L. Jones, the fellow since 1931, will be in charge of the new investigations of the Bausch & Lomb Optical Company at Mellon Institute.

CORNING EXPANDS FIBRE DIVISION

Two important developments in connection with their production of glass fibre were announced last month by the Corning Glass Works. Plant facilities of the Fibre Products Division are to be enlarged, and, the foundations for three new buildings, having a total area of 46,000 square feet, are now being dug. At the same time it was announced that Leslie W. W. Morrow, former editor of *Electrical World*, had been appointed general manager of the division.

Mr. Morrow brings to his new work a distinguished record of achievement and many contacts with industry. Following his graduation as an M. E. from Cornell in 1911, he served as an instructor there, then went to the University of Oklahoma as director of the school of electrical engineering. From 1918 to 1921 he was professor of electrical engineering at the Sheffield Scientific School at Yale University. Concurrently with his academic pursuits, Mr. Morrow was also serving as a consulting engineer for a number of power, industrial and utility companies, making tests, reports and investigations.

It was only six months ago that the Fibre Products Division started up production in a new factory which had been built for it in Corning, N. Y., about one mile away from the main plant of the Corning Glass Works. The three new units now under construction will stand close to the first and will have walls built of glass in place of brick.

The first of the new plant units will offer increased storage and shipping facilities, the second will provide additional manufacturing space, and the third will accommodate construction of an additional glass melting furnace. The buildings, it is expected, will be completed by March 1 to assist in meeting the increased demand for glass fibre.

● What is said to be the largest installation of invisible glass in the world is to be found in the New York showroom for Chrysler automobiles. There are more than 1,000 square feet of curved glass in the seven large windows. The illusion that no glass separates the passer-by from the interior of the showroom is complete.

METHODS OF FURNACE CONTROL

WHILE the type of furnace used by the glass industry for glass melting is essentially the same as the open hearth type furnace used by the steel industry, it is nearly always the latter that leads in economy and efficiency of furnace operation. This is especially true in the case of furnace control methods through which economy in fuel consumption may be attained. When it is considered that fuel is the most important raw material, both in weight and value, consumed in the manufacture of either steel or glass it is surprising to find that while the steel industry has long ago made rapid strides toward securing economies in fuel utilization, the glass industry has been slow to adopt the same methods.

The problem of control of glass or steel furnace combustion operations may be considered as two separate and distinct phases. The first is concerned with the proper regulation and control of the fuel and air mixture and with the maintenance of constant and correct draft conditions in the furnace. The second phase of the problem deals with the maintenance of constant and suitable temperature conditions in the melting chambers and regenerators.

The requirements of suitable controls for these phases are approximately as follows: A control of air supply that will provide a minimum excess at all rates of fuel B. T. U. input with sufficient flexibility to provide either a reducing or oxidizing atmosphere at the will of the operator; a stack draft control which will allow a minimum amount of air filtration, the maximum transfer of heat from the flame and gases of combustion to the glass and the maintenance of the necessary velocities of the gases through the furnace regenerators and stack; a reversal control that will give the combustion air the highest preheat consistent with the checker design and the physical characteristics of the checker brick.

In the past few years the steel industry has developed several different methods of control which meet, to various degrees, the above requirements. These methods may have several or all of the following features:

1.—Proportioning of Fuel and Air Supply:

Fuel measurement as a means of air supply control.

Maintenance of constant pressures of fuel and air regardless of the quantities being used.

Mixing fuels to maintain a predetermined quantitative B. T. U. input.

2.—Stack Draft Control:

Automatic control of exit gas fan speed or of the stack damper.

Changing the weight of the stack gases by the addition of atmospheric air.

3.—Checker temperature control:

Automatic or manual reversal of the regenerators through pyrometric control by predetermined high, low or differential temperature limits.

The control of combustion by proportioning fuel and air supply is accomplished by determining the fuel-air ratio required for a specified degree of combustion. By mechanical means the desired fuel-air ratio may always be maintained (and hence the degree of combustion) regardless of any changes that may occur in the amount of fuel being passed by the burners. In practice it is usually easier to use the fuel rather than the air supply as the basis of control.

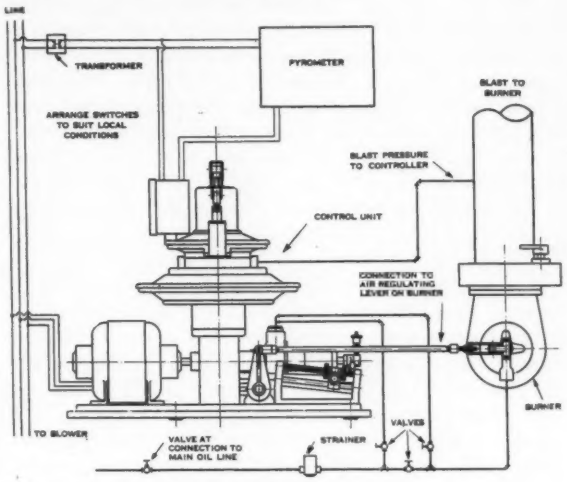


Fig. 1. Courtesy Johnson Manufacturing Co.

As an example of this method of combustion control the following is a description of a liquid fuel system in actual use in a steel plant. This system is based on the fact that a positive pressure pump connected in the fuel oil line to the furnace, with equal pressures at the inlet and outlet of the pump, will deliver liquid fuel in direct proportion to the speed of the pump. The pump therefore acts as a meter. By connecting a small blower or fan in line with the pump so that its speed is a multiple of the speed of the pump, the free delivery of air from the blower is a direct measurement of the volume of liquid fuel delivered to the furnace. The inlet of this blower is equipped with a suction pipe having an orifice at the end, so that the drop in pressure across the orifice may be used as a measure of the flow in liquid fuel. This drop in pressure is then balanced in a regulator against the drop in pressure across the inlet orifice of the fan supplying the air for combustion. Thereby, with the correct orifice relationship established, the proper amount of air for the desired degree of combustion of any flow of liquid fuel is secured.

Combustion control methods may be very readily tied in with temperature control systems. With the inclusion of thermocouples, pyrometers and suitable relays in the system it is possible to maintain both constant temperature and combustion conditions. The sequence of operations in the case of a fuel oil burning furnace is then as follows: If the furnace temperature drops, the pyrometer relay causes the oil valve to open and the supply of oil to the burners is increased. At the same time the increased flow of oil causes the combustion control system to function and the desired fuel-air ratio is thereby automatically maintained. Fig. 1 shows a diagramatic arrangement of such a system.

It is probably safe to say that, in most glass plants, the only method of combustion control practiced is an occasional Orsat gas analysis. Usually the determination of the proper fuel-air ratio is left up to the tank teaser's judgment with the result that countless useful B. T. U.'s are lost up the stack in the form of excess air or combustible gases. With automatic combustion

control methods such losses are eliminated and a high fuel efficiency attained.

With the adoption of fuel-air ratio control it becomes necessary to also adopt some suitable method of controlling or preventing air infiltration into the furnace system in addition to keeping constant the correct draft conditions in the furnace. This may be accomplished through the use of automatic draft control systems. One system that is being used extensively (shown diagramatically in Fig. 2) in the steel industry operates thus:

The control proper consists of a pressure control unit; an electrical relay; and a motor-operated damper drive. The pressure control unit is connected to the furnace by means of a short pipe. Changes in the furnace pressure cause the control to operate the relay which in turn operates the motor drive. The motor drive then adjusts the damper and the effective opening of the stack is either increased or decreased. The resulting change in draft returns the furnace pressure to the control point, the pressure control unit becomes adjusted and trips off the relay. As a check on the control system, a recording draft gage may be connected in the line from the furnace.

The use of draft control not only prevents a negative pressure in the furnace with its resulting infiltration of air but will also prevent the occurrence of changes in pressure due to variations in the fuel supply or changes in weather conditions. In addition, the stack draft is always under control with the result that the velocity of the combustion products through the furnace may be regulated to suit various conditions.

In the case of reversal control many glass plants attempt to control the reversal periods by using standard time intervals. This system is efficient and workable only when both sets of regenerators are thermally balanced. Such a condition is seldom attained and in practice the two sets of regenerators are nearly always thermally unbalanced. The preheated air temperature therefore varies considerably when the regenerators are not thermally balanced and reversal is accomplished by time intervals.

By reversing when the regenerators reach a predetermined temperature or when there is a predetermined temperature differential between the two regenerators, constant preheated air temperatures are assured. Reversal on a temperature basis is accomplished by the use of pyrometric installations in suitable parts of the regenerators. When the desired temperature is reached relays operate warning signals in the case of manual reversal or operate motor drives in the case of automatic reversal.

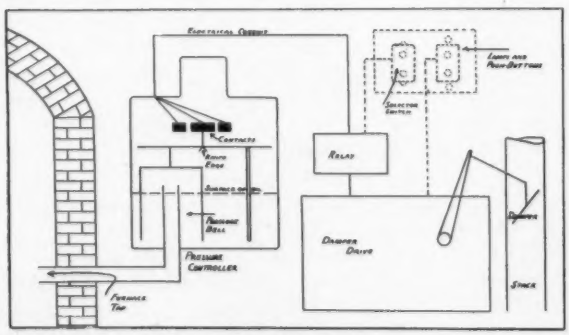


Fig. 2. Courtesy Leeds & Northrup Co.

The use of reversal control on a temperature basis will assure the delivery of preheated air at constant temperature to the furnace with the result that the furnace temperature will remain balanced and will not be affected by the reversal periods of the regenerators.

The adoption of these different methods of furnace control by the glass industry will lead to savings in fuel, an improved product through the elimination of many of the variables that cause cordy, stony or seedy glass, and increased life of the refractories. All of these are items of considerable importance when computing production costs.

It is important to remember when considering the adoption of such control methods that each furnace is an individual problem and that the experience of the instrument engineer is well worth considering and that complete cooperation between the furnace man and the instrument companies' engineers is necessary for the successful application of the principles of such control methods.

PONTALITE A TRANSPARENT PLASTIC

Highly transparent plastics offering new and varied applications to industry form one of the most active divisions of the rapidly growing plastics field. The latest of the transparent plastics to be announced is "Pontalite," scheduled for production early next year by the Ammonia Department and the Plastics Department of the du Pont Co. Chemically this transparent organic glass is the methyl ester of methacrylic acid (more briefly methyl methacrylate). It shares the lightness of the urea-formaldehyde, vinyl, and styrol types of plastics, but far exceeds them in transparency and brilliancy. It may be molded into complex shapes or subjected to machining, drilling and cutting. The monomer from which the plastic is made can be poured into molds and polymerized, or used to impregnate cloth, paper or wood.

In other physical properties, Pontalite exhibits an unusual combination of qualities. In addition to unique clarity, this resin has a high softening temperature, high tensile and impact strengths, good dielectric properties, low specific gravity, light-stability, good ultraviolet transmission, and is not attacked by the usual inorganic reagents and some of the more common organic solvents. Although the resin is softer than glass, it is more surface-resistant than most other thermo-plastics. One can readily restore original brilliance of a scratched surface by simple polishing procedure.

The resin, due to its unusual clarity, can be fabricated into delicate tinted shades and combined with varying amounts of dye or pigments, and the control of opacity promises to give wide latitude in the decorative effects that may be obtained. The glass-like transparency of the resin suggests many uses as glass substitutes if strength, lightness, ultraviolet transmissibility and ease of fabrication by molding are desired.—*Industrial Bulletin* of Arthur D. Little, Inc., Nov., 1936.

The Department of Commerce has listed the current requirements of foreign countries for American merchandise, varying from freight trailers to portable organs. Of particular interest is the great demand for American beer bottles. More detailed information may be obtained from the Bureau of Foreign and Domestic Commerce.

SPECIFICATIONS FOR LEAD GLASS IN CZECHOSLOVAKIA

By Dr. Ing. V. CTYROKY and Ing. M. FANDERLIK*

LEAD glass of various types is used as material for the manufacture of surface polished glass articles, known on the market as Lead Crystal Glass, as well as for the manufacture of "Gablonz Goods," which are glass imitations of a variety of gems. Its optical qualities (high refractive index, high relative dispersion) and its high specific gravity give the finished articles character. It is natural that the requirements for glass as material for this purpose vary with the product to be manufactured. The highest requirements are laid on glass material serving for the manufacture of gem imitations, the so-called Gablonz Goods. Altogether different qualities are required, on the other hand, from the glass intended for the hollow crystal glass table sets. From this reason it appeared necessary when devising standard quality specifications to limit several quality classes according to which the different sorts of glass could be located.

The classification may be divided into three sections:

1.—Glass of highest lead oxide content, suitable for the manufacture of the so-called Gablonz Goods.

2.—Glass of medium lead oxide content intended for the manufacture of hollow lead crystal ware.

3.—Glass of low lead oxide content intended for the manufacture of semi-lead glass articles of current use.

After investigation of the pertinent literature, and a systematic analytical research of a series of glass samples of most varied qualities and determination of their physical constants, the relationship between the lead-oxide content and the physical properties of glass, characterizing the actual appearance of the product, was disclosed. An exact definition of this relation is a very difficult task, and the work done and published previously on this subject by different authors could not be applied, because every glass works produces its glass in different composition, notwithstanding the actual content of lead oxide.

An exact dependability of the optical qualities of the glass on its lead oxide content may exist only in case of products of otherwise similar composition in which only the percentage of lead oxide varies. The Standard Specifications were intended to comprise all transparent glass sorts, disregarding the other components of the glass mass.

On all the samples, physical constants were determined as follows: Specific gravity, by weighing the sample in the air and in water. In some cases the pycnometric method was employed. Then cubes of one centimeter edge were ground out of the samples and their surface polished. These cubes were measured in the Pulfrich refractometer with a sodium light lamp to determine their refractive index for the sodium light. Then the refractive indices for the lines C and F were determined by means of a hydrogen Geissler tube and out of these the relative dispersion for each glass ($1/\nu$) was calculated.

In addition to these physical and optical determinations, the analytical determination of lead oxide was also made on most of the samples. This was to make possible the study of the relationship between the optical qualities of glass and its lead content; or at least to estimate in what limits this correlation with the lead content exists, even in very different types of lead glass.

In the following table are quoted the values found on several samples of glass:

Number of Sample	Specific Gravity	Refractive Index n_d	Relative Dispersiveness $1/\nu$	PbO Analytically per cent
		Czechoslovak Glass		
2	2,884	1,539	0,0210	24,02
3	3,187	1,576	0,0240	31,05
		German Glass		
19	2,564	1,521	0,0190	11,25
20	3,028	1,558	0,0229	29,8
		English Glass		
25	3,185	1,573	0,0240	35,45
26	3,072	1,563	0,0233	31,08
		French Glass		
29	3,150	1,571	0,0240	33,82
31	3,167	1,572	0,0239	35,27
		Belgian Glass		
33	2,829	1,535	0,0205	22,13

It is evident from these results that, though there may be an analogy between optical qualities and lead content to a certain extent, there are nevertheless marked deviations from an average dependability. This also satisfies our presumption that it is not sufficient for the definition of the ability of the glass to know its lead oxide content, but that an exact specification of the minimum value of the refractive index for the sodium light and the relative dispersiveness $1/\nu$ on which to some extent the brilliancy and the play of colors in a glass product depend, are equally necessary.

Apart from the general appearance of the glass product, its specific gravity is also a rather important commercial factor and very often is required. From this reason it was decided to limit also this value for the respective types of the lead glass.

The relationship of various properties of glass and the lead oxide content is shown in the following diagrams:

Fig. 1 demonstrates the relationship of the refractive index of the lead glass of lead oxide content under 40 per cent PbO.

Fig. 2 shows the relationship between the relative dispersion $1/\nu$ and the percentage of the lead oxide. Here also conditions are very similar to the case above.

Fig. 3 shows the relationship between the relative dispersion and the refractive index. Both optical properties are here correlated.

From a series of analyses of Czechoslovak and foreign glass sorts which are recognized quality products of distinct types known on the world markets we concluded: that the current lead crystal glass contains from 21 to 35 per cent of lead oxide and a current semi-lead glass not less than 10 per cent. Complying with the

* This paper by two members of the Glass Research Institute of Hradec Kralove, Czechoslovakia, was presented last July before Group I of the International Congress on Glass, England.

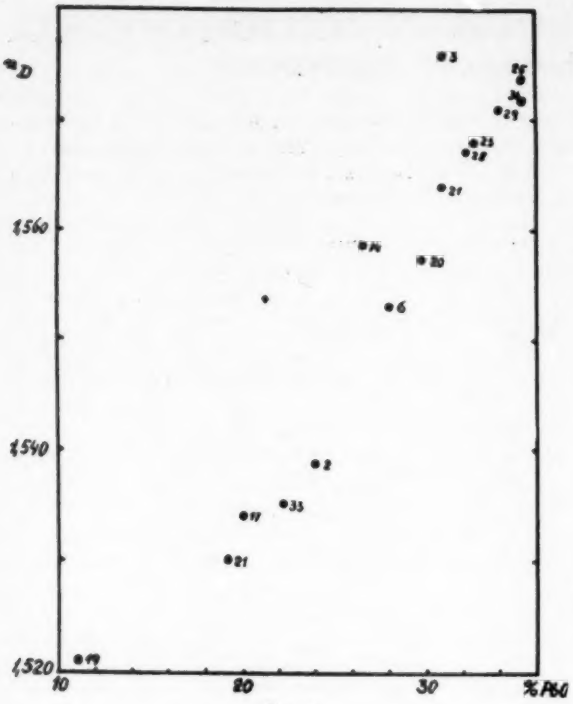


Fig. 1

wish of the consuming circles at present to keep the traditional high quality of the products in an adequate ratio with the price limits, the following classification was devised:—

1.—For the Czechoslovak lead crystal glass designated by the mark "Bohemian Lead Crystal" following values are specified: Minimum lead oxide content 20.0 per cent, minimum refractive index for the sodium light 1.530 and minimum relative dispersiveness 0.020. In addition to this a minimum for specific gravity of 2.78 g/cc is prescribed.

2.—For the semi-lead glass designated as "Bohemian Lead Glass" following values are specified: Minimum lead oxide content 9 per cent, minimum refractive index for the sodium light 1.519 and minimum relative dispersiveness 0.017. In addition to this a minimum for specific gravity of 2.56 g/cc is prescribed.

In both cases it was specified that the designation of "Bohemian Lead Crystal" and "Bohemian Lead Glass" would be permitted only upon the condition that all of the specified values were attained.

In the case of glass material for the manufacture of "Gablonz Goods" and the gem imitations, known in Czechoslavakia as "Composite Glass" or "Tin-Ware Glass" a somewhat different measure of classification was employed. The specification of the lead oxide content was dropped, for several reasons:—

1.—The name itself does not say that the material must necessarily be a lead glass.

2.—The main characteristics required from this type of glass are the appearance and the physical properties, which are supposed to be as close as possible to those of natural stones.

3.—As the hardness of the glass and the resistance against scratching is an important factor in case of gem imitations, freedom must be given to the manufacturers to make glass of that composition which, just from the point of view of hardness, they consider most satisfactory.

It was therefore intended to devise in this case only specifications for the *optical properties* characterizing the general appearance of the product, and the specific gravity.

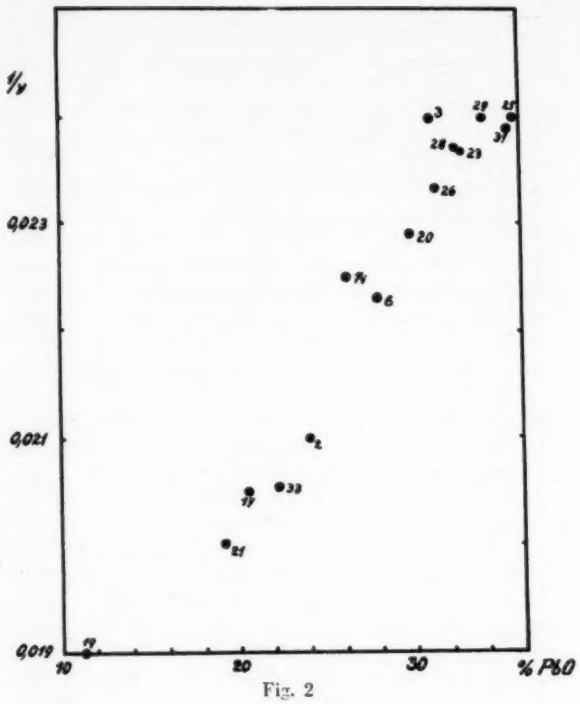


Fig. 2

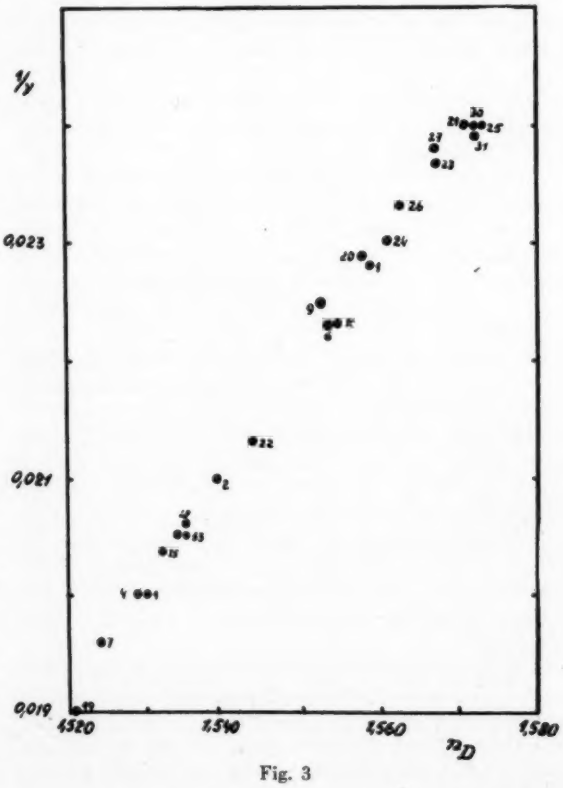


Fig. 3

SMALL TANK FURNACES

By RUDOLF HOHLBAUM, Engineer

TANK furnaces are known to be vastly superior to pot furnaces. It used to be admitted, however, that it was not possible to employ glass tanks except for large scale production of one single type of glass. This is an erroneous hypothesis, nevertheless; tanks are advantageous in many instances, even for the smallest production, down as low as 500 kg., (about 1100 lbs.) of workable glass per 24 hours.

These small tanks can be built either for intermittent service or for continuous operation with a ring. If they are suitably constructed, it is possible to melt in them, successively, the most diverse glasses, exactly as in a pot. If the melting tank is subdivided, different glasses can even be melted simultaneously in separate compartments. We might even consider the installation of a small tank in a pot furnace, if the latter was of the high port type.

If the complexities of manufacture require it, a small tank of adequate proportions will perform with as much facility as a pot furnace, and do so while retaining all the advantages of a tank furnace.

The operation of the tank is more economical than the operation of pots for a like production of glass if for no other reason than that losses arising from the failure of pots are thus avoided. The labor of melting is less costly than with pots for a given run, certain accessory expenses disappearing. The saving of fuel assured by a tank is very important, 25 per cent under the least favorable circumstances. This is due to the fact that, in the small tank, the ratio of production to the free space lost is much more favorable than in the case of a pot furnace.

The small tank offers great advantages for the manufacture of special glasses that require high temperatures and are often very destructive of the pots, for it can be brought to high heats without fear of accident or undue corrosion; above all, since we may use tank blocks made of materials well suited to the commodity produced and more resistant to the attack of the glass than pots can be. We know, for instance, that glass batches containing cryolite attack the pots severely even if we use the highest alumina-bearing clays for their manufacture. These clays analyze a maximum of 40 per cent of Al_2O_3. Under the most favorable circumstances, pots will resist four weeks of melting of cryolith glass batches. By adding alumina to the bonding clay, tank blocks containing from 60 to 70 per cent of Al_2O_3 are secured. In a glass plant, a cryolith batch was melted in a small tank—with such 60 per cent blocks—and in a pot furnace. The pots were made of Meissen and Grossalmerode pot clays. They resisted corrosion for about a week while the tank blocks were scarcely affected after six months and showed no appreciable washing out until after nine months in use. Not until they had given eleven months of service did they have to be replaced.

The quality of the glass produced in a tank furnace seems generally far superior to that of pot-made glass. Tank-made glass, when made well, is of unvarying quality without cords or ream, being free from the troubles that are too often present when working glass from the bottom of a pot. Very frequently, at the end of a run the pots are empty and are thus responsible for heavy losses in manufacture.

If we wish to melt glasses of different characteristics, simultaneously, in one tank furnace, the melting tank must naturally be subdivided. For each compartment, tank blocks of suitable attributes can be used, so that good results may be assured for all circumstances. Small tanks are frequently conceived as being day tanks, but they can also be operated as continuous tanks, especially for the manufacture of small articles like flasks, druggists' bottles, and preserve jars. The tank furnace is divided into a melting end and a refining end by a bridge-wall. The batch is melted in the one end, and gathered in the refining chamber which may, or may not, have a dog-house, care being taken to use a ring. The tank really operates like a large pot with two compartments, the one open, used for melting, the other closed, for the gather.

Small tanks may be heated with gas of low thermal content, with gas in conjunction with regenerators or recuperators, or with oil—depending entirely on the kind of fuel available. According to circumstances, gas low in BTU for instance, regenerators will be used by preference. With a better, producer—gas or with a coke-oven gas, a more conveniently handled recuperator would be preferred. In this instance, only the air would be heated in the recuperator, the gas coming to the burners at its normal temperature without any preheating to avoid any reduction of its thermal potency by reason of a possible depositing of soot in the recuperator tubes. It is more advantageous to pre-heat the air still more intensively by using up every last bit of the waste gases for this purpose. If crude oil or fuel oil are cheap, they are used with the combustion air heated, in order to get a flame that is free from soot. This air, like that for gas of low thermal content, is pre-heated in a recuperator.

Numerous types of small tank furnaces have been recommended. In a subsequent study of this subject, we expect to enlarge upon the matter because it is very much the order of the day. Its technical aspects have been greatly developed, and this system of manufacture will come into use, more and more, in the near future.

Outside of Belgium, such tanks have been received with a great deal of confidence by the industry, and they have been adapted to the most varied applications.

In certain instances, for quite special products, very interesting figures have been quoted, especially in the manufacturing of cast opals in white, in solid colors, and in marble effects. This kind of furnace can be used to great advantage for goblets and tumblers, and in the lighting-ware branch of the industry. Glass for modern lighting fixtures is generally made of white glass of a cryolite batch, with a transparent, colored glass flashed on. The cryolite batch is melted in a tank, the transparent glass, or glasses, in pots. The tank blocks being high in alumina, a regular cryolite glass that is free from cords or strings is obtained. The difficult and

(*Concluded on page* 427)

*Translated by A. H. Schottland from an article which appeared in *Verres et Silicates*, Sept. 25, 1936.

CUBA AS A MARKET FOR AMERICAN FLAT GLASS

By CHARLES H. DUCOTE

Assistant Commercial Attache, Havana

● Cuba is experiencing a tremendous building boom, and all reports indicate that this boom is to continue for some time to come. Thanks to the reciprocal trade treaty with Cuba, American exporters are placed in an excellent position to capture this business.

Particularly flat glass trade statistics show that Cuban imports of flat glass have trebled in the past three years. While the United States is still in the front rank of exporters, Germany and Belgium are securing the bulk of the increase in tonnage.

It is hoped that this article will bring home to our own manufacturers the importance of the Cuban market; that it will indicate to them that in order to share in the Cuban prosperity they must know the peculiarities of the market, what trade advantages they already have and what handicaps need to be adjusted, what types of products are wanted.

The information given is authentic and will be supplemented on request by the Department of Commerce. Thomas Burke, Chief of the Specialties Division, is keenly interested in expanding our export markets for glassware of all kinds, and will be found an able and willing consultant by all who seek his assistance.

As flat glass is not produced in Cuba, the annual consumption of window and plate glass may be considered equivalent to the annual imports of these materials into the Island.

Window glass is the most important of the items making up the flat glass group. Demand has shown steady growth since 1933 when only 30,490 pesos worth were imported. This figure was more than doubled during 1934. In 1935 and the first quarter of 1936, as may be noted from the following table further enormous gains were made in the sales of window glass. Although the United States supplies the major portion of the demand Belgian and German manufacturers also make large sales, hence a summary of the salient characteristics of the market will be of interest to determine whether there may be an opportunity of increasing the American proportion of the total trade.

Sales of American glass were stimulated by the Trade Agreement and a larger proportion of the demand since the pact went into effect is served by American manufacturers. A substantial volume of business is still handled by Belgian firms who quote prices in some categories considerably lower than those asked by firms in the United States. The latter have an important advantage in that they are able to make much more rapid delivery. On the other hand dealers complain that the high freight rates on glass shipments from the United States restrict the volume of orders placed with American firms.

Imports during recent years were as follows:

CUBAN IMPORTS OF WINDOW GLASS

	1934		1935		1936*	
	Kilos	Pesos	Kilos	Pesos	Kilos	Pesos
United States	123,783	12,701	274,541	39,420	140,974	32,386
Germany	161,592	15,797	231,680	18,494	43,797	2,488
Belgium	356,693	34,571	512,873	33,629	178,439	11,880
All others	28,149	2,851	79,773	13,452	5,353	1,650
Total	670,217	65,920	1,098,876	104,925	368,493	48,404

*First three months.

The principal types in demand are said to be those from size 40″ (combined length and width) to 100″, single strength, clear, 16 and 18 ounces; also the double strength in 40″ to 100″ (combined length and width) sizes, 21 and 24 ounces. There is a considerable demand for matt finish 40″ to 100″ 16, 18 and 24 ounces. Belgian manufacturers obtain a considerable volume of business in 18 and 24 ounce glass as these thicknesses are preferred in a great many instances over the 16, 21 and 26 ounce glass, offered by American firms selling the product in this market. Buyers consider that 16 ounce glass is suitable for picture framing and like uses, but is too light for glazing windows. The 26 ounce glass on the other hand is claimed to be unnecessarily heavy and therefore costly, for window glazing.

Distributors state that in the smaller sizes, say up to 60″ (combined measure), Belgian manufacturers dominate while in the larger types American manufacturers have the advantage. Preference has been expressed for the American products because of the superior packing thereof, which results in less loss from breakage in transit.

The business in plate glass is divided between crystal sheets, so-called, and polished plate. The former is used by furniture manufacturers for table tops and the like, in cheap show cases, very cheap mirrors, glass shelving and other applications where freedom from bubbles, waves and such minor defects is not required. Belgian competition is intense in this branch of the trade and American producers are said to obtain only a small part of the orders placed for this grade of plate glass. Orders are placed with American firms only when quick delivery is required, it is said. The principal thicknesses in demand are 3/16″, and 7/32″. Belgian prices in the 10—25 sq. ft. bracket in these thicknesses are said to be $0.08 and $0.09 per sq. ft. c.i.f., Havana, as against $0.14½ and $0.16 per sq. ft. c.i.f. Havana for American glass. American manufacturers have an advantage however, in that the import tariff on Belgian or German plate glass is at the rate of 4.50 pesos per 100 kgs. whereas products from the United States have a preferential of 40 per cent, giving a final import duty of 2.70 pesos per 100 kgs. for the latter. Consular fees on shipments from the United States also have the advantage of a rate of 2 per cent, as against 5 per cent for Germany and Belgium.

Polished plate glass, which is of higher quality than the crystal sheet, is used in the manufacture of mirrors, store fronts, and other applications where a high degree of "water whiteness", freedom from waves, stones and other defects are required. Sizes most in demand are those comprised within the brackets, 15 to 25 sq. ft.,

25 to 50 sq. ft., and 50 to 75 sq. ft. American glass is preferred in the smaller sizes, mainly because of its superior quality and competitive price. Belgian firms are said to produce a very good quality plate at a lower price than American glass in the larger sheets, and this glass is in good demand where the application requires high grade material.

Another item of importance in the flat glass trade is plate glass, imports of which during the last two full years and first few months of 1936 were as follows:

CUBAN IMPORTS OF PLATE GLASS

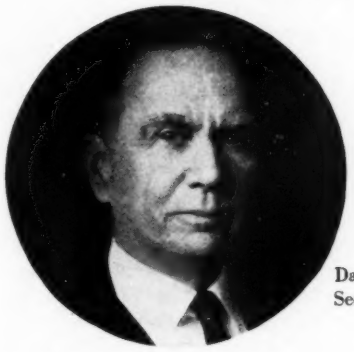
	1934		1935		1936*	
	kilos	pesos	kilos	pesos	kilos	pesos
United States ..	130,142	31,718	239,996	53,583	10,654	2,488
Germany	76,925	13,583	34,472	9,148	10,679	2,614
Belgium	213,694	41,185	128,538	24,046	14,150	1,301
All Other	40,332	9,283	31,393	8,341	3,126	772
Total	461,093	95,769	434,399	95,118	38,609	7,175

*First three months.

Almost all of the plate glass is imported with rough edges as the import duties are much higher and tariff preferential on American manufactures of this kind much lower than in the case of uncut glass. Only a few thousand dollars worth of "finished edge" plate are imported annually. There is some importation of glass slabs for sky lights, leaded glass, and gilded and engraved glass, and although the sales of these varieties are small the demand has increased along with that of the ordinary types of flat glass.

Flat glass is handled by importing distributors who purchase in many instances direct from the manufacturers. A very few European and American manufacturers work through commission agents in Havana. Plate and window glass are imported and distributed almost entirely by five or six firms. These concerns generally import through Havana and ship to the remainder of the Island, repacking where it is necessary to take care of small orders. Distributors are encouraged by the outlook in the flat glass trade and look for a continuation of the upward movement.

THE DEPARTMENT OF COMMERCE SENDS GREETINGS



Daniel C. Roper,
Secretary of Commerce.

THE Christmas season seems a singularly appropriate time for an official of the government to greet and congratulate one of the great American industries which his bureau strives to serve.

All too few are the opportunities which we have to express the feelings of friendship and admiration which we hold toward men, who, after all, represent the greatest single factor in our civilization, the business and industry on which rests the whole fabric of our national life. Today, I feel more strongly than ever the truth of something learned during 17 years in private industry—that no man or group of men can properly interpret the feelings and aspirations of another group without building an understanding based upon a strong foundation of mutual trust and co-operation.

In the United States we are looking hopefully toward an era of unequalled prosperity which may be sufficiently contagious to destroy the seeds of social and economic unrest which are so prevalent in the European area. The frustrated peoples of the Old World are looking to our leaders in the hope that we will expound the doctrine of "good neighborliness" through sound economic practices. They are convinced that destruction and carnage are inimical to prosperity and they believe that the American way—of fair appreciation for the right of all people to a reasonable share of comfort—will lead to peace and economic stability; to rationalism instead of nationalism. Reports from every corner of the earth verify that belief, and the glass industry, as a vital factor in the American economic scene, has a tremendous stake in shaping our leadership.

We therefore extend to you our heartiest seasonal greetings. We congratulate you on the splendid progress you have made this year along scientific and business lines. We want to develop a more intimate and cordial relationship with every part of the glass industry. The doors of our offices in Washington have neither locks nor latches for your members.

THOMAS BURKE
Chief, Specialties Division,
Bureau of Foreign and Domestic Commerce.

Ernest G. Draper, Assistant Secretary of Commerce.

Thomas Burke, Chief of the Specialties Division.

THE MAKING OF OPTICAL GLASS

By MURRAY R. SCOTT

Bausch & Lomb Optical Company

The object of this paper is to review briefly the general melting procedure and methods of manufacturing control used in the making of optical glass. The process described has been found to give good results over a long period of time and we hope will prove to be of interest to manufacturers of other types of glass.—The Editor.

BY OPTICAL glass we mean glass of suitable quality for use in making high grade optical instruments. This covers a large field and includes many instruments such as microscopes, telescopes, range finders and photographic lenses. The requirements for glass of this type are naturally very rigid and make necessary the use of manufacturing methods and control not generally used in making other types of glass. It must be made to meet the specifications for quality and optical constants, such as index of refraction and dispersion, as prescribed by the designer of the instrument in which it is to be used. The performance of the lens system used in any instrument depends very much upon both the design and the quality of glass used in making the lenses. The characteristics of good optical glass have been described so fully by Dr. F. E. Wright in his book, "The Manufacture of Optical Glass and of Optical Systems," that they will not be repeated here.

In the melting procedure used at the Bausch & Lomb glass plant, optical glass is melted in pots holding from 800 to 1,500 lbs. Open pots are used and only one melt is made in a pot. The pots are slowly heated in pot arches over a period of from 4 to 5 days. On reaching a temperature of approximately 1900° F. they are transferred to the melting furnace. Here they are heated to 2600° F. and burned for several hours before the batch and cullet is charged into them. They are filled by a hand operated ladle and in most cases the batch is allowed to melt between each fill. The first fill usually consists of about 100 lbs. of cullet having the same composition and optical constants as the batch being melted. This is followed in about one hour by a mixture of batch and cullet with the proportion depending on the amount of cullet available. From three to five fills are sufficient to fill the pot for most types of glass.

Soon after the pot is full and the batch is completely melted the stirring operation is started. For this a tapered hollow clay tube about two feet long and from three to four inches in diameter is used. This tube floats in the glass and is held in an upright position and moved through the glass by means of a water cooled rod. The rod has a square plug attached to one end at right angles to it, which fits into the top of the clay tube. The other end of the rod is attached to a stirring machine which moves the clay tube through the glass at the desired speed. The machine is so designed that the tube may be carried through the glass at a series of different speeds and will trace different sizes of circles, allowing the entire area of the pot to be covered. This makes it possible to follow the stirring schedule best suited for each type of glass. Most glasses are stirred in fairly rapid speeds through the fining period, the speed being gradually reduced as the cooling begins and the glass becomes more viscous. The stirring is continued until the end of the melt with the tube being removed just before the glass is taken from the furnace.

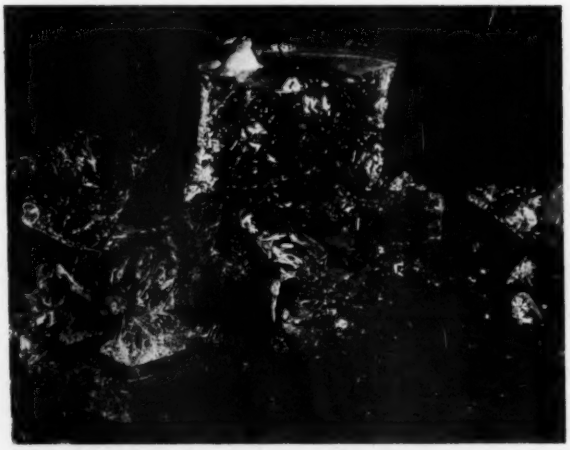
A plan, first introduced by Morey, of stirring for short periods between the fills is followed in making some types of glass. This speeds up both the melting and fining and reduces the total time required for a complete melt. At the present time practically all types may be melted on a 24 hour schedule or less.

The pot when removed from the furnace is placed on an insulated base and allowed to cool rapidly to approximately the annealing temperature. The surface is covered with an insulating powder about one hour after the pot is removed and the entire pot is covered with an insulated drum in from 3 to 6 hours depending on the type of glass. The insulation around the pot controls the rate of cooling and serves as an annealing furnace to slowly cool the glass. The drum is removed after three days, the surface insulation after four days, and the pot is broken away from the glass after five days. If the rate of cooling has been properly controlled the glass will come from the pot cracked into large irregular shaped chunks. These are inspected and then broken into smaller chunks for a more critical inspection using an optical instrument. The glass that passes this chunk inspection is then formed into square or rectangular slabs by reheating in refractory molds or by pressing. The slabs are then ground and polished on opposite ends or faces and given a final inspection.

The glass that is finally ready to send to the lens maker either in the form of moulded blanks or slabs is given a final annealing. This generally requires two to three weeks and is known as "fine annealing."

Manufacturing Control

THE results obtained in making optical glass depend very much upon the amount and type of control given each operation in the process. This is especially true of the melting and fining operations but it is essential that all steps be given close attention.



A pot of optical glass ready for inspection.

Raw Materials—The selection of raw materials is based primarily on their purity. Each is carefully chosen to be as free as possible from impurities, such as iron, that give color to the glass. The control of color is obtained entirely by the use of pure materials because decolorizers are never added due to their effect on the light transmission. In addition it is important that the materials be very uniform in composition to hold the optical constants within the narrow limits always specified.

Accurate chemical and physical tests are used both in making the proper selection and in testing the different shipments as received at the plant. All materials are shipped in dust tight containers and stored without unpacking until used. Also in cases of materials subject to changes in composition during storage the chemical tests are repeated a short time before use.

Weighing the Batch—The materials used in making the glass are accurately weighed, mixed and screened before charging into the melting pot. Some are mixed by machine but due to the large variety of glasses made, the majority are mixed by shoveling over by hand. Both the mixing machine and the mixing boxes are lined with wood to prevent the picking up of small amounts of iron. The size of batch made is carefully planned so that the entire amount weighed and mixed may be used in one melt. This helps in controlling the uniformity of composition and optical constants especially in making the dense lead glasses. All mixed batches are kept in covered boxes until used to prevent any possibility of contamination.

Glass Melting Pots—To make the control as complete as possible a pot house is operated in conjunction with the glass melting department. Here pots are developed to be suitable for making different types of special glasses. For example, a pot suitable for making a dense lead or barium glass will be different in composition from a pot used for a soda-lime or borosilicate glass.

The clays used are selected primarily for their freedom from impurities such as iron. Each type is purchased in as large lots as possible to insure better uniformity of the pots and each lot is tested when received. Careful attention is given to all steps in the pot making process. This includes weighing the batch, grinding and screening, mixing, ageing, building and drying the pots. Pot batches are always compounded

A stirring machine in position ready for use.

A clay stirring tube being removed from the mold.

to permit safe drying, burning and handling as well as to resist the corrosive action of the glass.

Burning the Pots—The pots are slowly heated in special pot arches having insulation on all sides, including the door. Burners are used on each side of the arch and burn through flues across the bottom and up the opposite inside wall to improve the uniformity of heating. The flow of gas to the burners is measured by a differential gauge and the temperature by a potentiometer recorder. All the usual precautions necessary to successfully burn large pieces of clay ware are carefully followed.

Glass Melting—The glass is melted in a single pot regenerative type furnace which, like most glass melting furnaces, are operated by hand. The furnace man in charge, however, is supplied with enough control equipment to allow him to maintain the proper furnace conditions at all times. Furnace temperature is measured by an optical pyrometer along with a single point recording pyrometer to serve as a check. The recorder also supplies a record of the furnace temperature throughout the melting schedule. In addition a record is kept of the hourly readings taken with the optical pyrometer.

The furnaces are heated by artificial gas having a B.T.U. value of about 540. The amount of gas used on each furnace is measured by meters and the rate of flow into the furnace by a differential gauge. A meter is used to record the pressure on the line and the B.T.U. value is checked each day. The control of the flame condition is obtained by frequently observing the type of flame and making the necessary adjustments, if it is not satisfactory. A record is kept of the hourly readings for each melt showing the flow of gas into the furnace, the air intake adjustment and the stack damper adjustment. These records are used as a guide by the furnace men in making future melts of the same kind of glass. The use of an automatic damper controller which changes the stack damper according to changes in the furnace pressure has proven to be of help. Also a pressure gauge to indicate the furnace pressure has been found useful in helping to control flame conditions.

A careful planned schedule giving the filling rate, the stirring procedure, the time temperature curve and

furnace adjustments is supplied for use as a guide in making each melt of glass. This schedule is followed as outlined except in cases where small deviations are necessary to take care of a pot that may melt or fine slower than usual.

Inspection—The glass that is finally accepted for use must pass through three rigid inspections. The chunks as they come from the pot are examined for bubbles, stones, color and other defects visible in ordinary daylight. The chunks that pass this inspection are immersed in a liquid having the same refractive index which causes the surfaces to disappear from view while they are examined for striae in parallel light. The chunks that are passed as being free from striae are moulded into square or rectangular slabs. Two opposite ends of these slabs are ground and polished for the final and most critical inspection. If examined in ordinary daylight even when looking through well polished surfaces the slabs will usually appear to be entirely free from striae. However, when examined by optical means a small percentage is almost always rejected for this defect. If 20 percent of the glass coming from a pot is found to be usable for making lenses it is usually considered satisfactory.

Annealing—The slabs of glass are given a final annealing immediately after the moulding process. This normally requires from two to three weeks during which they are cooled down from the annealing temperature to room temperature. The annealing furnaces or kilns are kept under very careful control with the temperature being reduced a few degrees each day.

The optical constants and the light transmission are measured on well annealed samples taken from each pot of glass.

● This huge 14-pot furnace at the Consolidated Lamp and Glass Co., Coraopolis, Pa., roared into action again on Nov. 1, marking the return of this old-line firm to normal production. Since this furnace was last in operation in 1932 it has been rebuilt in accordance with the latest furnace design. Its re-firing has been necessitated by the constantly increasing volume of business in illuminating glassware during the past few months. The transfer of the pots from the smaller reserve furnaces took the better part of a week and was accomplished without mishap. Restoring this, the largest furnace at the Consolidated plant, to active production will not only increase employment in Coraopolis, but will greatly increase the productive capacity of the plant, not only in tonnage but also in the variety of glass.

TESTING GLASSWARE PAID TRIBUTE

A high tribute to the glass industry's ability to produce accurate glassware for laboratory testing purposes has been paid by specialists at the New York State agricultural experiment station at Geneva, N. Y. "In recent years the method of manufacturing testing glassware has greatly improved," says an official statement. "It is evident that modern glass ware is being carefully made." The Geneva experiment station is in an excellent position to judge fairly whether or not testing glassware is accurate as, during 1935, 49,764 pieces of all kinds were tested there under legislative regulations, which have been in effect since 1899. A law enacted at that time made it the duty of the institution's director to examine all glassware used by dairymen in that state for what is known as the "Babcock Test." This is used to determine the butter fat content of milk purchased from farmers for the making of butter, cheese or other dairy products. In 1923 standardization of dairy testing glassware was extended to include bacteriological glassware.

During the early years of the testing of glassware, A. C. Dahlberg of the Geneva staff says the maximum error permitted was 0.2 per cent, which was then the smallest graduation on the milk test bottle. "This means," he continued, "that errors in results secured by the Babcock method might vary 0.2 per cent from the correct test, due to the test bottle alone. If two bottles were selected, representing extremes in inaccuracies, the tests secured with the two test bottles on the same milk sample might vary 0.4 per cent. Even on this lenient basis of testing milk test bottles, 76 bottles out of 2,259 tested the first year were rejected as inaccurate. In recent years the methods of manufacturing testing glassware have greatly improved and standards of accuracy enforced by the state have been made more rigid. Today all milk test bottles must be accurate within 0.1 per cent or less and there has been some discussion of reducing the tolerances still further.

"Standardization of dairy testing glassware was extended in 1923 to include bacteriological glassware. The urgent need for regulation of the accuracy of bacteriological pipettes was clearly shown the first year they were tested when 15,461 pipettes were examined and 618 rejected. In 1935 there were 10,223 bacteriological pipettes sent to the station for examination and only 17 were rejected. This compares favorably with the 39,541 pieces of Babcock glassware tested with 433 rejections. The larger number of these was due to imported glass with incorrect standards." All inaccurate glassware is broken and discarded, Mr. Dahlberg states. All accurate glassware is marked "S. B.," meaning "State Branded", by etching the letters in the glass with a sand blast. This accurate glassware goes into milk plants, condensories, ice cream or cheese factories and public health laboratories.

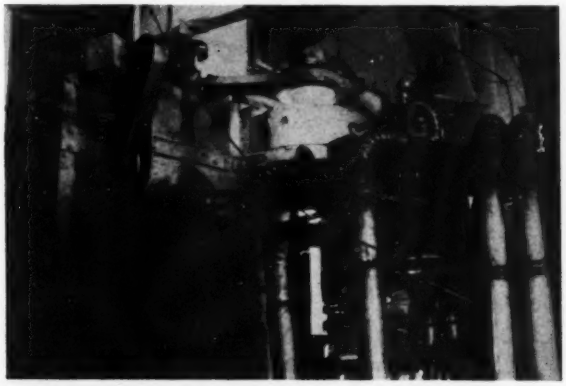
FOR SALE—8 mould O'Neill machine model No. 42 recently overhauled. Please communicate with Diamond Glass Company, Royersford, Pa.

FAIRMOUNT CHANGES FROM OIL TO GAS

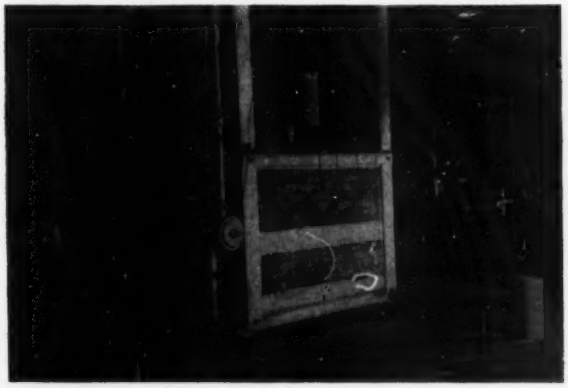
J. B. Nealey of the American Gas Association advises that the Fairmount Glass Co., Indianapolis, manufacturers of glass bottles, have found it necessary to change over from oil to gas firing. This change is reported to have been made to overcome certain difficulties experienced in maintaining a delicately controlled heat for their feeders. This is, of course, necessary to maintain the correct viscosity of the glass before it enters the forming machine.

Fairmount has 16 bottle machines fed from three melting furnaces of 35, 50 and 100 tons capacity, respectively. The feeders were re-designed for gas firing and equipped with 6 gas burners each. These fire at three different angles as shown on the drawing. Each feeder is 80 inches long and 26 inches wide, outside dimensions. Built of brick, they are lined with 3 inches of refractory clay and covered, on the outside, with 3 inches of insulation. The troughs for the molten glass are 12 inches wide and the capacities of the discharge holes are regulated by movable plugs.

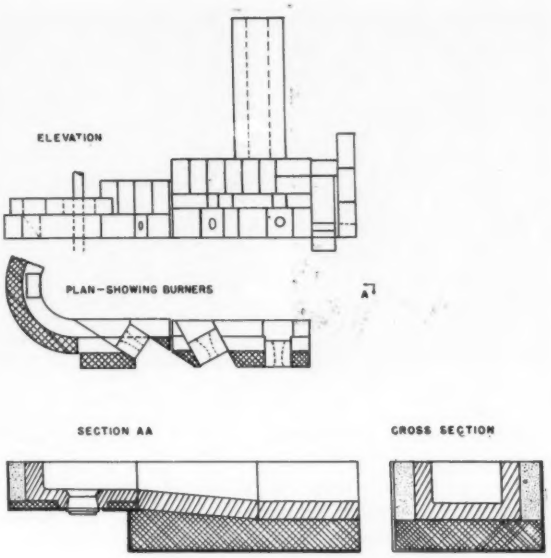
The firing system is what is known as the low pressure inspirator type. The three nozzle type gas burners on each side of the feeder, are manifolded to a single venturi mixer in each case. Pressure air inspirates gas at atmospheric pressure in just the amount necessary for perfect combustion. As the shop air is at 42 lbs. pressure, this must be reduced and the reduction is accomplished by a simple high pressure inspirator placed in the air line. Mixing 70 per cent atmospheric air with 30 per cent pressure air with this inspirator, which is connected just ahead of the low pressure inspirator, furnishes the latter with air at one pound pressure. This is the pressure required for properly entraining the gas. By leaving the gas valve full open, the amount of heat is controlled by a single valve in the high pressure air line.



Gas fired glass feeder between day tank and bottle machine.



Gas fired furnace for heating refractory plugs, etc.



GAS FIRED GLASS FEEDER

Improvements effected by the changeover to gas are said to include better control over viscosity of glass; greater uniformity of heat; less maintenance and lost time; increased life of feeder; increased production; reduction in rejects; and improved clarity of glass. The latter improvement was brought about through the elimination of carbon streaks, a condition said to be found in oil firing.

The clay plugs and tubes used in the feeders are preheated in a novel furnace, novel in that it has no doors only openings in the top. This furnace is 4 x 5 x 4 feet high and is of the usual brick and refractory construction. Heat is supplied by a single gas burner of the same type as described. The top is of tile blocks with 15 suitably sized holes through which the work protrudes. The parts to be heated are suspended from a superstructure by wires and pulleys. The lehrs are 75 feet long and are now heated with a single tunnel type gas burner. Practically all the improvements enumerated for the feeders, viscosity excepted, followed this changeover.

PLATE GLASS CONTINUES TO GAIN

The production of plate glass, which has continued to gain steadily this year, showed a still further increase in October with 20,752,657 square feet as compared to 19,552,775 square feet in September and 16,592,803 square feet produced in the corresponding month last year, October 1935. This brings the total production during the first ten months of 1936 to 177,613,639 square feet.

The recent vogue for "trailer" living has inspired Simon Slobodkin to design several new sets of tableware for use in these perambulating bungalows. The several styles carry such names as Yellowstone, Yosemite, Sunset Trail, Mohawk Trail, Oregon Trail, etc.

George Macbeth

Amory Houghton

CORNING AND MACBETH-EVANS JOIN FORCES

The acquisition of the Macbeth-Evans Glass Co. by the Corning Glass Works has been announced by joint statement by the officers of the two companies. Negotiations leading to the purchase have been completed and approved by the Boards of Directors of both companies and ratification by stockholders is expected in time to permit operation on a joint basis by Jan. 1. The two manufacturing plants of Macbeth-Evans at Charleroi, Pa., and Elwood, Ind., will be operated as divisions of the Corning Glass Works. However, according to President Amory Houghton of Corning, "In general, policies of production and personnel of the Macbeth-Evans units will be continued precisely as heretofore."

The Macbeth-Evans Co., whose head offices are at Charleroi, Pa., was founded in 1872 by George Alexander Macbeth. He was succeeded by his son, George D. Macbeth, who has been president of the company since 1927. The original company, known as the Macbeth Glass Co., was merged in 1899 with the Thomas Evans Co., which had been established in 1869. The Macbeth-Evans Glass Co. established its early reputation in manufacturing lamp chimneys for kerosene lamps. From this early start in the lighting field, the Macbeth Co. has become recognized as the leading manufacturer of standard and special glass for lighting purposes, manufacturing glass shades and reflectors, street lights, home, factory and office lighting glass, automobile headlight lenses and railroad signal glass. Other items include electric meter covers, gasoline filling station pump covers, godet wheels for the rayon industry. The company has long been famous for its precision work for the U. S. Navy and Federal lighthouse service, manufacturing lenses for lighthouses all along the Atlantic Coast plain, and for all of the lighthouses controlling traffic in the Panama Canal. More recent developments include glass construction blocks for building purposes, architectural glass and the current manufacture of glass tiles for the roof of the Mid-Town Tunnel under the Hudson River in New York. Macbeth is also a large manufacturer of tumblers and of pressed tableware of all varieties.

Since the early 19th century, the history of progressive glassmaking in America has been largely identified with the Houghton family. Nearly 100 years ago Amory Houghton founded a glass works in Massachusetts. Succeeding him, his son, Amory Houghton, Jr., transferred the business to Corning, N. Y.

Under the third generation of the family, Arthur A. Houghton, and Alanson B. Houghton (former United States Ambassador to England and to Germany), the Corning Glass Works became recognized as one of the world's leaders in glassmaking. The Corning laboratories, the largest and most advanced glass laboratories in the world, have made possible by their research work such a remarkable achievement as the recent casting of the giant 200-inch telescope disc. Pyrex brand ware and Corning industrial and scientific glass are now used in every country. Recent developments include glass construction blocks, whose use as a building material is rapidly growing, and glass fibres as insulating material.

Today Corning Glass Works is under the guidance of the fourth generation, Amory Houghton, President, and Arthur A. Houghton, Jr., a Director of the company and President of Steuben Glass, Inc.

The acquisition of the Macbeth-Evans by Corning Glass Works is of particular interest in allowing for expansion of the constantly growing business of Corning Glass Works in its many fields of specialized glass manufacture. It brings together two companies whose research and development has been outstanding in different fields of the glass business.

GLASS USED FOR HIGHWAY MARKINGS

Among the most interesting new uses which have been developed for glass recently is for highway markings. Fred H. Korff, Inc., New York industrial engineers, have advised The GLASS INDUSTRY that they have completed all development work for a project which will utilize "millions of pounds of small glass spheres to assist in preventing accidents."

The development of the so-called "Refract-O-Lite System" involves a compound which promises to take the place of the present traffic and zone markings. Small round glass spheres, .015 inches in diameter, are spread on the compound while it is still wet. The following advantages of the use of these glass spheres compared to present road marking systems are cited by Mr. Korff:

"1. Is 2000 per cent more brilliant at night and on dark days.

"2. Can be seen for hundreds of feet at night and has a glow similar to a silver strip.

"3. Is far more durable, cannot be worn off in a few days or weakened by the sun and withstands perfectly the effect of all liquids ordinarily found on a roadway.

"4. Is far more valuable for bad curves, dead ends of streets and dark intersections.

"5. Practically eliminates the effect of ultra-violet rays, which is one of the main reasons why paints break down."

NEW STANDARDS FOR LABORATORY GLASS

Readers of The GLASS INDUSTRY, who are concerned with laboratory glassware, are advised that the National Bureau of Standards has printed revised standards on "Interchangeable Ground-glass Joints, Stopcocks and Stoppers." This new commercial standard, CS21-36, supersedes the former standard, CS21-34. The new edition retains all existing sizes of joints, stopcocks and stoppers, but adds two new sizes of full length joints and a series of medium length joints. The standards became effective for new production, May 15, 1936. Printed copies are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents each.

EQUIPMENT AND SUPPLIES

FLOW METER HANDBOOK

The Brown Instrument Co., Philadelphia, has just published a Handbook on Flow Meter Engineering, which covers every phase of flow meter engineering principles, designs, applications and installations. Information is given on the following subjects: general flow meter engineering, orifice design, steam flow measurement, water flow measurement, liquid flow measurement, air and gas flow measurement.

This information is contained in a handsome volume of 164 pages, printed on highly coated paper and durably bound with Spanish grain leather. The handbook is illustrated with charts, photographs and sample problems.

For copies of the *Brown Flow Meter Engineering Handbook,* address the Brown Instrument Co., Wayne and Roberts Ave., Philadelphia. The price is $2.00 a copy.

DIP-O AND SCREEN-O AGENTS

The A. C. Horn Co., Long Island City, N. Y., has been appointed exclusive agents for the United States and possessions of two leading Etchall products, Screen-O and Dip-O. As the names imply, Screen-O is for the screen process and Dip-O is for dipping. When a glass surface is first screened with Screen-O, it is said to be possible to make a second screening with paint, giving a practically indestructible adhesion. The Horn Co. also advises that it is with Dip-O possible to frost glass objects entirely or partially by dipping.

The Board of Directors of the General Refractories Co., Philadelphia, has announced the appointment of the following officers: Lionel Y. Green as vice-president in charge of operations, Russell P. Heuer as vice-president in charge of research, and Drew M. Thorpe as vice-president in charge of sales.

TRUSS FRAME BELT CONVEYOR CARRIER

Stephens-Adamson Manufacturing Co., Aurora, Ill., have recently developed a new truss-frame, sealed ball-bearing, belt conveyor. This carrier is of the three-roll in line design with outer rollers inclined to give the belt a 20 degree trough. The whole roller assembly is tilted to center the belt without guide rollers and particular effort has been made to produce a carrier that would minimize wear and tear on the conveyor belt. All parts are made of steel and malleable iron. The rollers are built of 5″ diameter steel tubing with ends smoothly rounded over the pressed steel and plates to prevent any tendency to fray the belt. Roller ends are recessed to house the bearings and allow rollers to be closely spaced to eliminate danger of pinching belts. Renewable, cartridge type ball-bearings are used throughout. The unique truss type frame is said to be unusually light and rigid, with the load carried by a tension rod.

NEW ROD STRAIGHTENER

An improved rod straightener and shear machine has just been announced by the American Foundry Equipment Co., Mishawaka, Ind. This machine was designed for the reclamation of rods, bolts, wire and nails to reduce scrap piles and save on labor costs. Rapidity of operation in both straightening and shearing is said to be limited only by the speed of the operator in feeding the machine. Sizes range from a small hand operated unit with a maximum straightening capacity of ¼-inch rods to a large compressed air unit with a maximum straightening capacity of 2½-inch rods.

Leeds & Northrup Co., Philadelphia, announce the establishment of a new office at 75 Pearl St., Hartford, Conn.

LINK-BELT CHANGES

The Link-Belt Co., Chicago, announces that P. B. Engstrom has been appointed the company's authorized distributor for crawler shovels, draglines and cranes, and locomotive cranes in the Los Angeles and Southern California territory. B. Howard McNeal has been transferred from Memphis, Tenn., to Philadelphia, where he will specialize on the sale of crawler and locomotive cranes to industrial concerns. Ed. F. Carey, at Philadelphia, and Chester S. Lewis, at New York, will continue as the company's district representatives in their respective territories, specializing on the sale of crawler shovels, draglines, and cranes.

CATALOGS RECEIVED

Power Plant Measuring Instruments, Telemeters, Automatic Controls. Broadside 160. Leeds & Northrup Co., 4904 Stanton Ave., Philadelphia. This publication is in two sections: the first summarizes specific instrument uses in electrical and mechanical operating departments, while the second illustrates and describes instrument models.

Ladrillos Refractories, and *Firebrick with a Reputation.* Harbison-Walker Refractories Co., Pittsburgh. The first of these catalogs, which has both Spanish and English texts, is for the use of consumers of refractories in Spanish speaking countries. The latter is intended primarily for domestic use.

Mir-o-Meter Measures, Indicates, Records. S. F. Bowser & Co., Inc., Fort Wayne, Ind. Specifications and diagrams of a sytsem which measures, indicates and records the quantity of oil or tar being delivered to a furnace. In other words Mir-o-Meter is designed to check the amount of fuel consumed.

Here's the Answer to Your Temperature Problem. Brown Instrument Co., Philadelphia. A colorful broadside describing Brown thermometer controllers. It includes a complete description of Con-Tac-Tor mercury switches.

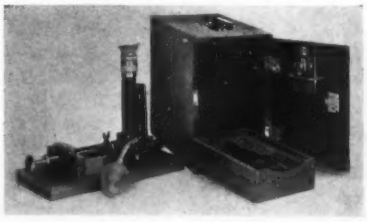
All Welded Dippers. Bulletin D-6. Harnischfeger Corporation, Milwaukee. Full details and specifications as to construction and weight-saving features of P. & H. all-welded dippers are given.

Representative Applications for Amsco Alloy Castings. American Manganese Steel Co., Chicago Heights, Ill. An illustrated folder suggestive of the many industrial applications.

Balopticons and Accessories. Catalog E-11. Bausch & Lomb Optical Co., Rochester, N. Y. A fully illustrated description of instruments for still projection, which may be profitably utilized in instructing employees.

A NEW DUST COUNTER

For use in determining the degree of danger of dusty operations, Bausch & Lomb have developed (see The Glass Industry, Nov. 1936, p. 393, for full description of the instrument) and are offering to industry through the Willson Products, Inc., Reading, Pa., an instrument which is said to simplify in a remarkable manner the problem of dust control. This new Dust Counter combines in one unit the necessary air sampling device and a dark field microscope viewing and counter system. No accessory laboratory equipment is needed. Suitably cased for transporting, the complete outfit weighs only 12½ pounds.



● The new Dust Counter recently developed by Bausch & Lomb and now being distributed through Willson Products, Inc., Reading Pa.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.15
52% and 48%	lb.	.10	.12½-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per 100 lb.		...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	...	Po. or Gr. .25 / Cry. .25½
Aluminum hydrate ($Al(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	.12	.12½
Antimony oxide (Sb_2O_3)	lb.	...	.12¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite)			
90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	38.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
(Commercial, 25% Selenium)	lb.	...	.90
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.0625
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	.90-.95
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate			
100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_3O_4)			
In bbls.	lb	...	1.41
In 10 lb. tins	lb.	...	1.51
Copper oxide			
Red (Cu_2O)	lb.	...	.20
Black (CuO)	lb.	...	.15¾
Black prepared	lb.	..	.22
Cryolite ($Na_3Al F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0770	...
In 5 Ton lots	lb.	...	.08
Less than 5 Tons	lb.	...	.085
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75	.
Litharge (PbO) (New York Prices)	lb.	.0670	...
In 5 Ton lots	lb.	...	.07
Less than 5 Tons	lb.	...	.075
Magnesium carbonate ($MgCO_3$)	lb.	.0610	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0275
Manganese, Black Oxide			
In Paper bags	ton	47.50	50.50
In Burlap bags	ton	49.50	52.50-57.50
In Casks	ton	51.50	54.50-59.50
Neodymidm oxalate, 50 lb. drums	lb.	...	$3.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.09
Powdered	lb.	...	.09½
Potassium carbonate			
Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅛
Hydrated 80-85%	lb.	.06	.06¼-.06⅛
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	...	.27
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	.0545	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	..	.19
Powder blue	lb.	...	.18¾-.19¼
Rare earth hydrate			
100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.13
Rouge	lb.		Po. or Gr. .13½ / Cry.
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	.95	...
In barrels	Per 100 lb.	1.35	...
In bags	Per 100 lb.	1.10	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06⅝	.07
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	...	.08⅛
Sodium fluosilicate (Na_2SiF_6)	lb.	.06½	.0725
Sodium hydrate ($NaOH$) (caustic soda)			
Flake	Per 100 lb.	2.70	...
Solid	Per 100 lb.	2.30	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97%			
Bulk	Per 100 lb.	1.255	...
200 lb bags		1.34	1.39
100 lb. bags		1.375	1.425
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50 1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	.	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70 4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.38½
Tin oxide (SnO_2) in bbls.	lb.	...	.55
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	2.25
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO)			
American process, Bags	lb.	.05¼	.05½
White Seal, 150 lb. bbls.	lb.	.07	.07¼
Green Seal bags	lb.	.06¼	.06½
Domestic White Seal bags	lb.	.06¾	.07
Red Seal, bags	lb.	.05¼	.06
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.05

SMALL TANK FURNACES

(*Concluded from page* 417)

costly replacement of pots is completely dispensed with. Needless to add, the capacity of the tank can be adapted to the amount of cryolith glass required.

In conclusion, we may make a few remarks on the subject of cleaning small tank furnaces. If we are to melt a glass of a new color in a tank, the tank will have to undergo a cleaning, just as a pot would. The cleaning of the tank is much simpler, and more nearly perfect, than the cleaning of a pot. The glass in the tank is worked out to the limit of possibility, then the heat is raised to the point where the residue, having reached a state of fluidity, runs down the side-walls and flows to the bottom. The bottom being inclined toward the taphole, the glass accumulates at the vent, nothing being required beyond opening the outlet. We know by experience that the cleaning of a pot with scraping tools is much the slower method and that, as far as results are concerned, they are never as good as those to be had with the small tank.

CERAMIC COURSE IN CALIFORNIA

Opening date of a course in Ceramic Technology, conducted by Dr. Willi M. Cohn, ceramic consultant of Berkeley, California, has just been announced by the University of California Extension Division. Classes will be held in Oakland, beginning Friday, Jan. 22. The course is planned for members of the ceramic industries who are already familiar with one phase or another of manufacturing or handling ceramic products. A broader knowledge of the basic fundamentals applied to the various branches of the ceramic industry may help in drawing conclusions for the particular line of work followed by the individual, Dr. Cohn believes. Those who are planning later to take ceramic courses in one of the Universities offering a full ceramic curriculum may get a general idea of fundamental sciences applied to ceramic problems. Interest in ceramic work is increasing in California, Dr. Cohn believes, partially because of the interesting raw materials the State affords.

SODA ASH PRODUCTION INCREASED

The production of soda ash in the United States in 1935 amounted 2,508,559 tons, an increase of 8.3 per cent as compared with 2,317,011 tons reported for 1933, according to Director William L. Austin, Bureau of the Census, in a special preliminary release based on data collected in the biennial census of manufacturers taken this year. The increase in production has been steady since 1931 when only 2,275,416 tons were produced. However, it should be noted that the figures for 1935 are preliminary and therefore subject to revision.

FROSTING GLASS CHEMICALLY

Writing in the German publication *Sprechsaal* (69, No. 6, 75-76), E. Arnot describes a rapid dipping process for the chemical frosting of glass. The success of the operation is said to depend largely on the correct preparation of the bath, which is a solution of two parts of hydrofluoric acid, four parts of ammonium fluoride and one part of soda.

MORE GLASS FOR AUTOS

Nearly 60,000,000 square feet of glass were utilized in 1936 by the Fisher Body division of General Motors in the production of bodies for the 1936 Chevrolet, Pontiac, Oldsmobile, Buick, La Salle and Cadillac. Consumption is expected to be even greater during the next 12 months since the wind shield and window openings of the new Unisteel turret top body are larger.

NAVY SPECIFIES FIBROUS GLASS

Naval authorities are now specifying fibrous glass for insulation on all modern United States naval vessels, according to a report received by The GLASS INDUSTRY. The reason for this is said to be that the material does not shrink even in continuous use on rough water where the pitching of the ships might tend to loosen the fibres.

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